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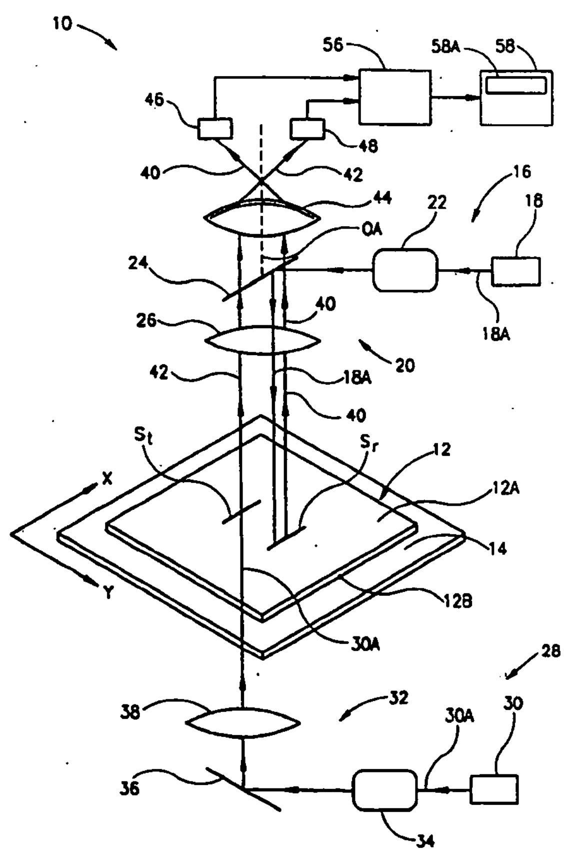
(57) Abstract

A method and an apparatus for an optical inspection of an object (12), having upper (12A) and lower (12B) faces, so as to detect defects existing on the object. First and second beams (118A, 130A) of an incident radiation are produced and directed onto the object. A light component (140) of the first incident beam, which is reflected from one face of the object, and a light component (142) of the second incident beam, which is transmitted through the upper and lower faces of the object, are simultaneously sensed. First and second images, formed, respectively by reflected and transmitted light components are acquired and analyzed so as to provide data indicative of the defects.



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Optical Inspection Method and Apparatus

FIELD OF THE INVENTION

The present invention is in the field of optical inspection techniques and relates to a method and a system for inspecting patterned objects such as, for example, photomasks, printed circuit boards (PCBs) or the like.

BACKGROUND OF THE INVENTION

There is a great variety of optical inspection systems having a common goal for locating defects existing on the patterned surface of an inspected object. The term *"patterned surface"* signifies such a surface which is formed with regions having different optical properties in respect of an incident radiation.

An inspection system of the kind specified typically comprises means for illuminating an object to be inspected, acquiring images formed by light reflected from the illuminated object, and image processing. However, if the inspected object is a photomask, flexible printed circuit board (PCB) or the like, whose patterned surface typically comprises transparent and opaque regions, the acquired images formed of light reflected from the illuminated surface are not indicative of such 'defects' as foreign particles, for example, of

dirt or dust, which may occasionally be located in the transparent regions. Indeed, it is known that a surface of such particle is not mirror like, and, accordingly, light returned from the particle is irregularly reflected, scattered light. The problem is very essential when using the photomask as a phototool in PCB, graphic arts and printing industries.

There have recently been developed methods and systems wherein the inspection is performed by means of illuminating an object and acquiring and processing images formed of reflected and transmitted beams of light. Such systems are disclosed, for example, in U.S. Patents Nos. 5,572,598 and 5,563,702. The systems in both patents employ a so-called 'scanning technique', wherein an illuminating laser beam is generated and focused onto a pixel defining spot on the surface of an object to be inspected. The illuminated beam is deflected in an oscillatory fashion so as to sweep the spot across the inspected surface. The system is adapted for three different modes of operation. According to the first and second modes, so-called "Transmitted Light Inspection Mode" and "Reflected Light Inspection Mode", the object is point-by-point inspected by means of detecting either transmitted or reflected light, respectively. These modes of operation are timely separated. The third mode of operation, which is aimed at defects classification, is based on detecting both reflected and transmitted beams of light. A single laser beam of incident radiation is directed onto the patterned surface of an object through light deflection means and is either reflected or transmitted, or partly reflected and partly transmitted by the object. The intensity of the incident beam is determined before its interaction with the object. Two separate detectors are accommodated at opposite sides of the object and detect transmitted and reflected beams resulting from this interaction. To this end, the system comprises separate directing optics for receiving the transmitted and reflected beams, respectively, and directing them onto the detectors.

This approach is based on that the interaction of an incident beam with an object to be inspected causes changes in beam's intensity, which changes depend on reflectivity and transmission of the respective region of the object. Hence, by appropriately detecting the intensities of the incident beams and reflected and transmitted beams, respectively, before and after the interaction, each inspectable point, or pixel, on the surface can be represented in a so-called 'T-R space', namely by a point with coordinates corresponding to the transmitted and reflected signal values produced at that point.

However, the system requires very complicated arrangements for illuminating and collecting optics. Indeed, the illuminating arrangement should be provided with the light deflection means and detector appropriately accommodated in the optical path of the incident beam so as to determine the beam intensity prior to the interaction with the object. This complicates and extends the optical path of the incident beam. Moreover, the use of a single beam of incident radiation results in an unavoidable requirement for locating the collecting optics, as well as the detectors for sensing the reflected and transmitted beams, at opposite sides of the object.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide novel method and apparatus for automatic optical inspection of an object by means of detecting reflected and transmitted light components of an incident radiation.

There is provided, according to one aspect of the invention, a method for an optical inspection of an object, having upper and lower faces, so as to detect defects existing on the object, the method comprising the steps of:

(a) providing first and second beams of an incident radiation;

(b) directing the first beam of the incident radiation onto the object and

sensing a light component reflected from one face of the object;

(c) directing the second beam of the incident radiation onto the object and sensing a light component transmitted through the upper and lower faces of the object;

(d) simultaneously acquiring first and second images of the object, wherein the first image is formed by the reflected light component and the second image is formed by the transmitted light component; and

(e) analyzing said first and second images so as to provide data indicative of said defects.

The term "defects" used herewith signifies certain undesirable conditions of the object such as, for example, existence of foreign particles located on the object.

Thus, the idea of the present invention is based on the following main features. The first and second beams of incident radiation are produced and directed towards the object for focusing them onto the upper face. It is understood that, generally, each of the incident beams can be both reflected and transmitted by the different regions of the object. In other words, each of the incident beams, depending on the region of its interaction with the object, may be partly transmitted and partly reflected resulting in, respectively, transmitted and reflected light components. To this end, what is actually detected by two image sensors are, respectively, that light component of the first incident beam which is reflected from the object and that light component of the second incident beam which is transmitted through the object.

Generally, the first and second incident beams can be directed onto the object from the same side thereof, that is from either the upper or the lower face. In this case the sensors and associated directing optics are located at opposite sides of the object. It should be noted that it is advantageous to

illuminate the object from opposite faces. This enables the sensors to be placed at one side of the object and, accordingly, a common directing optics to be employed for receiving both the reflected and transmitted light components and directing them onto the respective sensors.

Thus, the reflected and transmitted light components are, preferably, directed onto the different sensors via a common optical system appropriately accommodated in the optical paths of the both light components. It is understood that, accordingly, means should be provided for successfully separating the different light components so as to be sensed by the different image sensors. To this end, two alternating embodiments of the invention are exemplified.

According to one embodiment, the first and second beams of the incident radiation are simultaneously directed onto different portions of the object. More specifically, they illuminate, respectively, first and second spaced-apart, parallel, identical strips of the upper face. The relationship between the two illuminated strips and the common optical system is such that the strips extend symmetrically relative to the optical axis of the common optical system. The optical system actually projects the strips onto the first and second image sensors, which are, preferably, line sensors. Hence, a pair of spaced, parallel lines of the object is imaged. It is understood that the dimensions of the line are defined by a field of view of the image sensor, the width a of the line being substantially smaller than that of the illuminated strip. The space between the two illuminated strips is adjusted so as to minimize an overlap region between the two images. The space d between the two imaged lines satisfies the following condition:

$$d = n \cdot a$$

wherein n is an integer such that $n \geq 1$.

According to an alternative embodiment of the invention, the first and second beams of the incident radiation illuminate the same portion of

the upper face, which portion is in the form of a strip. To this end, the first and second beams of the incident radiation are formed of light having either different wavelengths, or different polarizations. In the case of different wavelengths, the common optical system comprises a suitable beam splitter, for example, a dichroic beam splitter. In the case of the different polatizations, the common optical system is provided with appropriate beam polarizer device based, for example, on a double refraction effect.

The first and second beams of the incident radiation may be produced by either two light sources, or by a single light source adapted for generating a beam of light. If the single light source is employed, the generated beam is directed towards the object via a beam splitter, which splits it into the first and second beams of the incident radiation.

Preferably, the image sensors are of a kind adapted to receive a light signal and provide an electric output representative thereof. For example, charge coupled device (CCD) cameras, or bi-directional time delay integration (TDI) sensor may be employed.

In order to successively inspect the whole object, it is supported for sliding movement within an inspection plane along two orthogonally oriented axes. It is appreciated that in order to allow for so-called "double side" illumination, the object may be supported on a transparent slab, or, alternatively, on a frame supporting solely the periphery region of the object. As a result of the inspection, each point on the upper face of the object is represented by so-called 'reflected' and 'transmitted' images. Comparing these images to each other enables to locate the defects, if any, on the object. For that purpose, the output signals provided by the image sensors are transmitted to a processor operated by a suitable software for comparing the first and second images to each other.

According to another aspect of the present invention there is provided an apparatus for an optical inspection of an object, having upper and

lower faces, so as to detect defects existing on the object, the apparatus comprising:

(i) an illumination system for producing first and second beams of an incident radiation and simultaneously directing them onto the object;

(ii) a sensing system mounted for sensing a light component of the first incident beam reflected from the upper face and a light component of the second incident beam transmitted through the upper and lower faces of the object, and for providing output signals representative thereof;

(iv) a light directing system accommodated in optical paths of the reflected and transmitted light components for directing them onto the sensing system; and

(v) a processor coupled to the sensing system for receiving and analyzing said output signals representative of the reflected and transmitted light components and for providing data indicative of said defects.

Thus, the present invention enables to inspect an object by simultaneously illuminating it by two incident beams of light and detecting reflected and transmitted light components of these incident beams, respectively. In other words, in comparison to the above U.S. Patents, each point of the inspected object is represented by both "T-map" and "R-map", i.e. "transmitted image" and "reflected image". This simplifies the analyzing procedure. Additionally, owing to the provision of the common optical system for directing the reflected and transmitted beams onto the different sensors, and the above solutions for successful separation between the reflected and transmitted beams, the construction and operation of the apparatus can be significantly simplified.

More specifically the present invention is used for inspecting a

photomask which is typically in the form of a polished transparent substrate whose upper surface has a plurality of spaced-apart regions coated by a thin opaque layer such as, for example, chromium. The upper surface of the photomask represents a pattern in the form of transparent and opaque regions. Defects, which can be detected by the method according to the invention, may also be in the form of through-holes in the opaque regions and/or width variation of these regions. It is understood that the opaque and transparent regions of a photomask would be represented by bright and dark regions in the 'reflected image' and by dark and bright regions, respectively, in the 'transmitted image'. If a foreign particle is located in the transparent region, it will appear as a bright spot on a dark background in the reflected image and *vice versa* in the transmitted image. If a foreign particle is located in the opaque region, solely the image sensor responsive to the reflected light component will detect it. Such particle will appear as a dimmer spot on the bright background in the reflected image. The other kinds of defects such as, for example, through-holes in the opaque regions or width variation of these regions will be detected by both the reflected and transmitted beams.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how the same may be carried out in practice, several preferred embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a block diagram illustrating the main components of an apparatus for optical inspection of a patterned object, according to one embodiment of the invention;

Figs. 2 and 3 more specifically illustrate the main principles of operation of the apparatus of Fig. 1;

Fig. 4 is a graphic illustration of the main principles of operation of an

optical system of the apparatus of Fig. 1;

Figs. 5a to 5f are schematic illustrations of images of the illuminated portion of an upper surface of the object during sequential steps of operation of the apparatus of Fig. 1;

Figs. 6a and 6b are schematic illustrations of two images of a region of the upper surfaces of the object; and

Fig. 7 is a block diagram illustrating the main components of an inspection apparatus, according to another embodiment of the invention; and

Fig. 8 is a block diagram illustrating the main components of an inspection apparatus, according to yet another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, there is illustrated an apparatus, generally designated **10**, for inspecting a photomask **12**. The propagation of beams of light is shown here schematically solely in order to facilitate the understanding of the main principles of the construction of the apparatus **10**. The photomask **12** is typically in the form of a polished transparent substrate having upper and lower surfaces **12a** and **12b**, respectively. The upper surface **12a** is formed with a pattern (not shown) having a plurality of spaced-apart regions coated by a thin opaque layer such as, for example, chromium. In other words, surface **12a** is formed with transparent and opaque regions. The photomask **12** is supported at its periphery region on a frame **14** mounted for sliding movement along mutually orthogonal axes x and y. Alternatively, a sliding base formed of a transparent material may be employed for the same purpose of slidingly displacing the photomask **12** within an inspection plane in a manner to provide illumination access to the lower surface **12b**.

The apparatus **10** comprises an illumination assembly, generally at **16** mounted at the upper side of the photomask **12** for illuminating its upper surface **12a**. The assembly **16** includes a light source **18**, producing a beam of

light **18a**, and an optical system **20**, accommodated in the optical path of the beam **18a**. The optical system **20** includes an anamorphic optics **22** typically comprising a cylindrical lens or plurality of such lenses, which are not specifically shown, a beam splitter **24** and an objective lens **26**. All these components of the optical system **20** are well known *per se* and, therefore, need not be described in more detail, except to note that they enable a desired shape of the beam **18a** to be obtained and focussed onto the photomask **12**. As shown, the beam **18a** illuminates a strip S_r of the upper surface **12a**.

Further provided is an illumination assembly, generally designated **28**, mounted at the lower side of the photomask **12** for illuminating its upper surface **12a**. Similarly, the assembly **20** includes a light source **30** producing a beam of light **30a**, and an optical system **32** accommodated in the optical path of the beam **30a**. The optical system **32** comprises an anamorphic optics **34**, a mirror **36** and a condenser lens **38**. The beam **30a**, being transmitted through the transparent lower surface **12b**, illuminates a strip S_t of the upper surface **12a**. It will be understood that the provision of the mirror **36** is optional and depends solely on the location of the light source **30** relative to the surface **12b**.

As further schematically shown in Fig. 1 and more specifically in Fig. 2, the beam **18a** impinges onto the surface **12a** and is reflected from reflective regions, if any, disposed within the strip S_r, resulting in a reflected beam **40**. The incident beam **30a**, being transmitted through the transparent lower surface **12b** of the photomask **12**, impinges onto the upper surface **12a** and is transmitted through transparent regions, if any, within the strip S_t, producing a transmitted beam **42**.

An optical system **44**, typically comprising a collecting lens or plurality of such lenses (not shown), is located at the upper side of the photomask **12** so as to be in the optical paths of both the reflected beam **40** and transmitted beam **42**. The system **44** has its optical axis shown in dotted

line **OA**. The system **44** directs the beams **40** and **42** onto line sensors **46** and **48**, respectively, thereby projecting two geometrically separated strips S_r and S_t into two imaged lines L_r and L_t. The image L_r is formed by light reflected from the strip S_r illuminated by the beam 18a, while the image L_t is formed by light transmitted through illuminated strip S_t. As more specifically illustrated in Fig. 3, in order to render the image quality at both sensors equal, the configuration is such that the illuminated strips S_r and S_t extend symmetrically relative to the optical axis **OA**.

It is understood, although not specifically illustrated, that the dimensions of the imaged lines L_r and L_t are defined by the field of view of each of the sensors **46** and **48** and are substantially smaller than those of the strips S_r and S_t. The sensors **46** and **48** are of a kind adapted for receiving light signals and generating electrical outputs corresponding thereto such as, for example, a conventional line-type CCD camera.

Fig. 4 illustrates the intensity distributions of the beams **40** and **42** which are in the form of two lobes **50** and **52**, respectively. It is appreciated that the spacing between the two illuminated strips S_r and S_t is arranged so as to minimize an overlap region **54**, thereby reducing crosstalk between the two images.

Turning back to Fig. 1, coupled to the sensors **46** and **48** is a processor **56** receiving the electrical outputs of the sensors **46** and **48**. The processor **56** is operated by suitable software carrying out an image processing technique capable of analyzing the imaged lines L_r and L_t by means of comparing the electrical outputs to each other and of providing information indicative of defects, if any, on the photomask **12**. The electrical outputs may also be compared with corresponding reference data which may be stored in a database of the processor **56** or derived from another photomask or from another part of the same photomask being inspected. The construction and operation of the processor **56** do not form a part of the present

invention and therefore need not be more specifically described. The information generated by the image processor **56** is output to a computer device 58 and displayed on its screen **58a**.

Alternatively, although not specifically shown, the processor **56** and the computer device **58** may be combined in one integral unit. The light sources **18** and **30** may be replaced by a single light source for generating a beam of radiation, in which case the generated beam is directed onto the inspected photomask via a beam splitter so as to be split into two separate beams for illuminating the photomask from opposing sides.

The operation of the apparatus **10** will now be described with reference to Figs. 5a-5f, partly illustrating images of the upper surface **12a** of the photomask **12** during the inspection. Initially, two strips are simultaneously illuminated (not shown) in the above described manner and two lines Lr_1 and Lt_1 are imaged. The lines Lr_1 and Lt_1 are identical having the same width a and length b and are aligned in a spaced-apart, parallel relationship along the y axis. A space d between the lines Lr_1 and Lt_1 is defined as follows:

$$d=n \cdot a \qquad (1)$$

wherein n is an integer $n \geq 1$, being equal to 1 in the present example.

At a next operational stage, the support frame **14** moves the photomask a certain preset step H_1 in a direction D_1 along the axis y, which step satisfies the following condition:

$$H_1=n_1 \cdot a \qquad (2)$$

wherein n_1 is an integer $n_1 \geq 1$, being equal to 1 in the present example. A further pair of lines Lr_2 and Lt_2 is imaged by the sensors **46** and **48**, respectively, and corresponding electrical outputs are transmitted to the processor **56**. Meanwhile, the sliding movement of the frame **14** in the direction D_1 results in a further displacement of the photomask the same step H_1, and a pair of lines Lr_3 and Lt_3 is imaged. As clearly seen in Fig. 5c, the

lines Lt_1 and Lr_3 coincide, which means that the corresponding strip of the surface **12a** has now been sequentially illuminated by the beams **30a** and **18a**. Figs. 5d and 5e illustrate, in a self-explanatory manner, the sequential increase of the number of such imaged lines corresponding to those strips illuminated by both beams of the incident radiation.

Hence, a slice, generally at B_i, of the surface **12a** is strip-by-strip inspected by step-by-step displacing the photomask **12** in the direction D_1 along the axis y. It is understood that the beginning of the inspection is stipulated such that the lines L_r'-L_r'' and L_t'-L_t'' corresponding to those strips illuminated by either of the beams **18a** or **30a**, respectively, are associated with a so-called 'margin', non-patterned region of the surface **12a**.

In order to inspect an adjacent slice B_{i+1} of the surface **12a**, the sliding frame **14** is moved a preset step H_2 in a direction D_2 along the axis x, which step H_2 is defined as follows:

$$H_2=b \qquad (3)$$

Thereafter, the photomask **12** is step-by-step displaced the same distance H_1 in a direction D_3 along the axis y. As shown, in the pair of simultaneously imaged lines L_r and L_t of the slice B_{i+1} the 'reflected' and 'transmitted' images are located in a reverse relationship relative to the direction of the displacement of the photomask, in comparison to that of the pair of simultaneously imaged lines Lr_1 and Lt_1 of the slice B_i. To this end, the image processor **56** is provided with a suitable software for controlling its operation so as to consider the respective changes in the direction of movement of the photomask **12**. Additionally, although not specifically shown, optical sensors may be appropriately accommodated at either side of the frame **14**.

It is important to note that if a pair of time delay integrated (TDI) sensors is employed as the imaging sensors **46** and **48**, they should be of the so-called 'bi-directional' kind. The construction and operation of such a 'bi-directional' TDI sensor are well known *per se* and do not form a part of the

present invention.

Turning now to Figs. 6a and 6b, there are more specifically illustrated the imaged lines Lt_1 and Lr_3, which correspond to the same illuminated strip on the surface **12a**, which strip is sequentially illuminated by the beams **30a** and **18a**. It is assumed that the portion of the upper surface within the illuminated strip includes both transparent and opaque regions, generally designated **60** and **62**, and that foreign particles **64** and **66** are located, respectively, in the transparent and opaque regions **60** and **62**. As clearly shown, the transparent and opaque regions **62** and **64** are in the form of bright and dark areas, respectively, in the 'transmitted' image Lt_1 (Fig. 6a), while being in the form of dark and bright areas, respectively, in the 'reflected' image Lr_3 (Fig. 6b). As for the foreign particles, it is known that a surface of such particle is not mirror like, and, accordingly, light returned from the particle is irregularly reflected, scattered light. Therefore, both the transmitted and reflected beams **40** and **42** are indicative of the existence of the particle **64** located within the transparent region. The particle **64** appears as light fall-off, i.e. dark spot on the bright background **60**, in the 'transmitted' image Lt_1 and as a brighter spot on the dark background **60** in the 'reflected' image Lr_3. The existence of the particle **66** located on the opaque region **62** may be detected solely by the reflected beam **40**, appearing as a dimmer spot on the bright background in the 'reflected' image Lr_3.

It is also appreciated that, should the plane of location of the particle **64** be identified, namely the upper or the lower surface of the photomask **12**, this may be achieved by slightly shifting the upper surface **12a** along the axis **OA**, so as to be out of the focal plane, and detecting the changes in the electrical output. Additionally, it is understood, although not specifically shown, that both the 'reflected' and 'transmitted' images will be indicative of such 'defects' as through-holes in the opaque regions and missed chromium coating presenting a so-called 'width variation defect'.

During the movement of the photomask **12** along the axes y and x as described above, the processor **56**, to which the electrical signals generated by the sensors **46** and **48** are continuously fed, analyzes these electric signals and produces data indicative of the condition of the photomask **12**. The processed data may be in the form of a list showing in respect of each 'defect' its type and coordinates, which list is displayed on the screen **58a**.

Reference is now made to Fig. 7 illustrating the main components of an apparatus, generally designated **100**, which is constructed and operated according to another embodiment of the present invention. Those components which are identical in the apparatuses **10** and **100** are indicated by the same reference numbers, in order to facilitate understanding. The apparatus **100** inspects the photomask **12** supported on the sliding frame **14**. Two illumination assemblies **116** and **128** are provided for illuminating the upper surface **12a** of the photomask **12** from its opposite sides. The assemblies **116** and **128** are generally similar to those of the apparatus **10**, each comprising a light source for emitting a beam of incident radiation and a suitable optical system accommodated in the optical path of the emitted beam. In distinction to the apparatus **10**, the light sources **118** and **130** produce, respectively, light beams **118a** and **130a** of different wavelengths λ_1 and λ_2. The beam **118a** is directed through the optical system **20** onto the surface **12a** so as to illuminate a strip S_n and be reflected from opaque regions, if any, producing a reflected beam **140**. The light beam **130a**, in turn, passes through the optical system **32** so as to impinge onto the surface **12a** and illuminate the same strip S_n, producing a transmitted beam **142**. The reflected and transmitted beams **140** and **142** are projected via an optical system **144** onto the image sensors **46** and **48**, respectively. To this end, the system **144**, in addition to the collecting lens **44**, comprises a dichroic beam splitter **145**. The dichroic beam splitter is a well known color-selective device which is widely used for

transmitting a particular band of spectral energy and reflecting any other.

It will be readily understood, although not specifically shown, that the operation of the apparatus 100 is generally similar to that of the apparatus 10. Each illuminated strip S_n is projected by the optical system 144 into two imaged lines (not shown). The photomask 12 is sequentially displaced along the axis y a certain preset step. It is appreciated that this step is, preferably, equal to the width of the imaged line so as to, on the one hand, avoid an overlap between the images and, on the other hand, speed up the inspection. Upon inspecting a slice of the photomask, the latter is displaced along the axis x a certain step which is, preferably, equal to the length of the imaged line.

Referring to Fig. 8, there is illustrated an apparatus **200** constructed and operated according to yet another embodiment of the invention. Similarly, those components which are identical in the above described embodiments and the apparatus **200** are indicated by the same reference numbers. The apparatus **200** is capable of illuminating a strip S of the upper surface **12a** of the photomask **12** by two beams of incident radiation **218a** and **230a** having different polarizations. To this end, the optical systems **220** and **232** comprise beam polarizer devices **234** and **236** accommodated in the optical paths of the beams **218a** and **230a**, respectively. Alternatively, each of the light sources **218** and **230** may be of a kind adapted for producing a polarized light beam. Hence, reflected and transmitted beams **240** and **242** are of different polarizations. The dichroic beam splitter **145** of Fig. 7 is replaced by a beam polarizer device **245** of a kind capable of splitting the different polarizations. Such beam polarizer devices are known, typically comprising a polarization sensitive medium, for example, in the form of a birefringent cell or multi-layered dielectric structure. It is appreciated that light component returned from a foreign particle located in the opaque region of the upper surface of the photomask, would be, due to reflection and

diffraction effects, a depolarized scattered forward light. This increases the contrast of particle's appearance on the bright background in the 'reflected' image.

Those skilled in the art will readily appreciate that various modifications and changes may be applied to the preferred embodiments of the invention as hereinbefore exemplified without departing from its scope as defined in and by the appended claims. In the method claims which follow, characters which are used to designate claim steps are provided for convenience only and do not apply any particular order of performing the steps.

WHAT IS CLAIMED IS:

1. A method for optically inspecting an object having upper and lower faces for detecting defects existing on the object, the method comprising the steps of:

a) providing first and second beams of an incident radiation;
b) directing the first beam of the incident radiation onto the object and sensing a light component reflected from one face of the object;
c) directing the second beam of the incident radiation onto the object and sensing a light component transmitted through the upper and lower faces of the object;
d) simultaneously acquiring first and second images of the object, wherein the first image is formed by the reflected light component and the second image is formed by the transmitted light component; and
e) analyzing said first and second images so as to provide data indicative of said defects.

2. The method according to Claim 1, wherein the step of acquiring the first and second images comprises directing the reflected and transmitted light components onto first and second image sensors, respectively.

3. The method according to Claim 2, wherein the first and second beams of the incident radiation are directed onto the object from the opposite faces thereof, and further comprising the step of;

directing the reflected and transmitted light components via an optical system mounted in optical paths of the reflected and transmitted light components onto the first and second image sensors accommodated at one side of the object.

4. The method according to Claim 1, wherein the steps of directing the first and second beams of the incident radiation onto the object further comprise manipulating said first and second beams of the incident radiation to

illuminate first and second parallel spaced-apart corresponding portions of the object.

5. The method according to Claim 4, wherein each of said first and second portions of the object are in the form of a strip.

6. The method according to Claim 4, wherein

the first and second beams of the incident radiation are directed onto the object from the opposite faces thereof;

the reflected and transmitted light components are directed onto, respectively, first and second image sensors, accommodated at one side of the object, via an optical system mounted in optical paths of the reflected and transmitted light components; and

the first and second portions extend symmetrically relative to an optical axis of said optical system.

7. The method according to Claim 1, wherein

the first and second beams of the incident radiation are directed onto the object from the opposite faces thereof; and

the first and second beams of the incident radiation are formed of light having different wavelengths.

8. The method according to Claim 1, wherein

the first and second beams of the incident radiation are directed onto the object from the opposite faces thereof;

the first and second beams of the incident radiation are formed of light having different polarizations.

9. The method according to Claim 4, wherein the first and second images of the first and second portions are in the form of two lines, each having a width *"a"* and a length *"b"*, the width *"a"* being substantially smaller than the width of the respective portion, a space *"d"* between lines being such as to satisfy the following condition:

$$d = n' a$$

wherein "*n*" is an integer such $n \geq 1$.

10. The method according to Claim 1, wherein the step of providing the first and second beams of the incident radiation comprises providing first and second light sources each generating a beam of light.

11. The method according to Claim 1, wherein the step of providing the first and second beams of the incident radiation comprises providing a light source generating a beam of light and directing the generated beam of light towards the object via a beam splitter, which splits the generated beam of light into the first and second beams of the incident radiation.

12. The method according to Claim 1, further comprising the step of:
supporting the object for sliding movement along two orthgonally oriented axes within an inspection plane so as to provide said first and second images of each point of the object.

13. The method according to Claim 1, wherein the analyzing of the first and second images comprises comparing the images to each other.

14. An apparatus for an optical inspection of an object, having upper and lower faces, so as to detect defects existing on the object, the apparatus comprising:

i. an illumination system providing first and second beams of an incident radiation simultaneously directed onto the object;

ii. a sensing system mounted in the vicinity of the object and simultaneously sensing a light component of the first incident beam reflected from the upper face of the object and a light component of the second incident beam transmitted through the upper and lower faces of the object and providing output signals representative thereof;

iii. a light directing system directing the reflected and transmitted light components onto the sensing system; and

iv. a processor coupled to the sensing system for receiving the output signals representative of the reflected and transmitted light components

and for analyzing the signals so as to provide data indicative of said defects.

15. The apparatus according to Claim 14, wherein the illumination system comprises two light sources for generating, respectively, said first and second beams of the incident radiation.

16. The apparatus according to Claim 14, wherein the illumination system comprises a light source for generating a beam of light and a beam splitter for splitting the generated beam into said first and second beams of the incident radiation..

17. The apparatus according to Claim 14, wherein the illumination system comprises a directing optics for directing the first and second beams of the incident radiation onto, respectively, the opposite faces of the object.

18. The apparatus according to Claim 14, wherein the illumination system comprises a directing optics for directing the first and second beams of the incident radiation onto, respectively, first and second parallel, spaced-apart portions of the object.

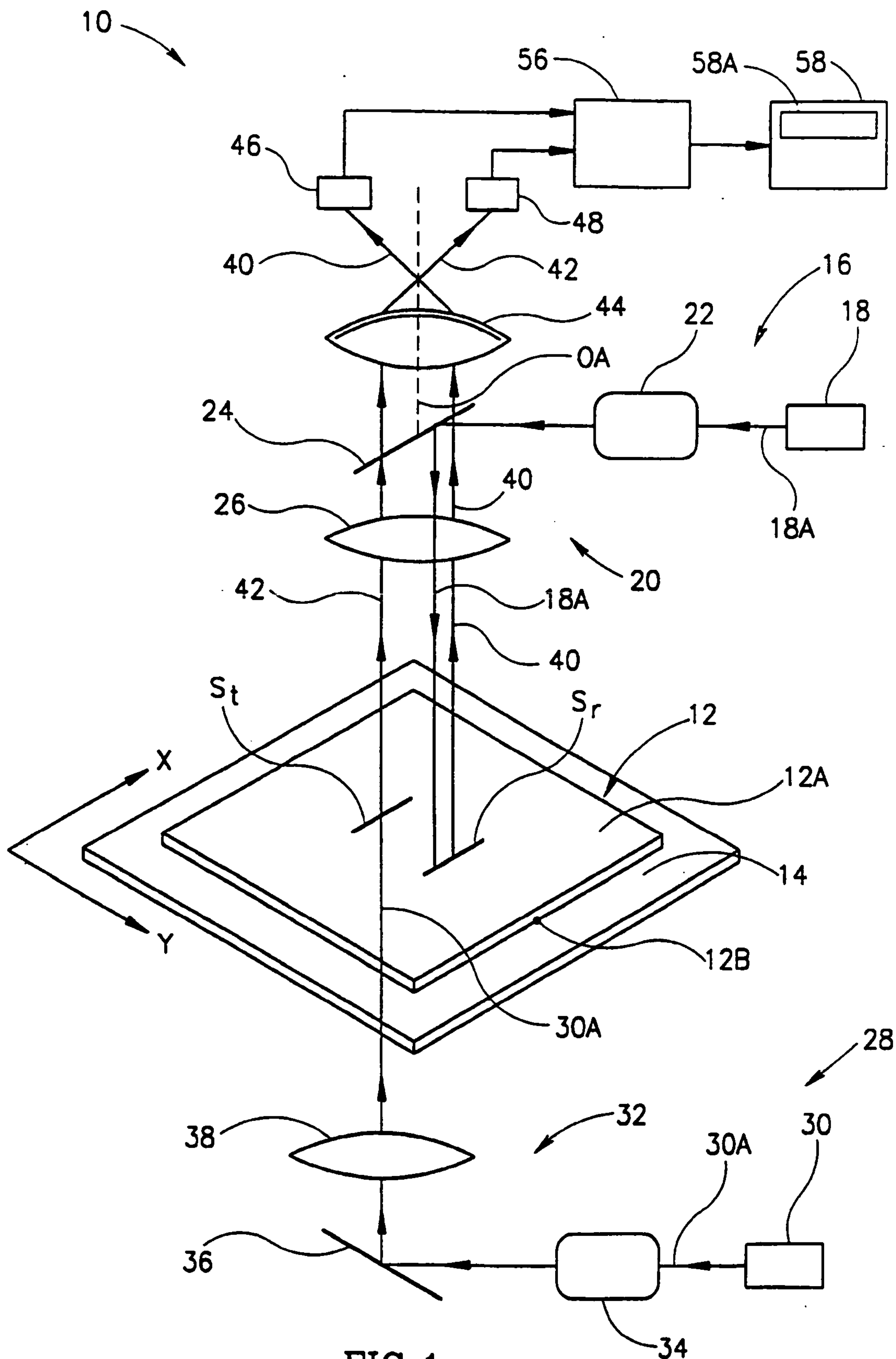
19. The apparatus according to Claim 14, wherein said first and second beams of the incident radiation are formed of light of different wavelengths.

20. The apparatus according to Claim 14, wherein said first and second beams of the incident radiation are formed of light of different polarizations.

21. The apparatus according to Claim 14, wherein the sensing system comprises first and second image sensors for detecting, respectively, the reflected and transmitted light components.

22. The apparatus according to Claim 17, wherein the light directing optics and the sensing system are accommodated at one side of the object.

23. The apparatus according to Claim 14, and also comprising a support base for supporting the object for sliding movement along two orthogonally oriented axes within an inspection plane.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42
18A
40
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Sr
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X
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Y
12B
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30A
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34

FIG.1

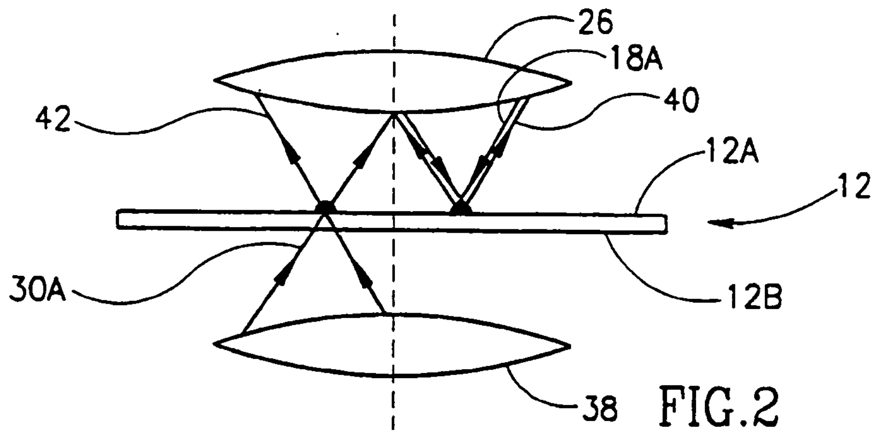


FIG.2

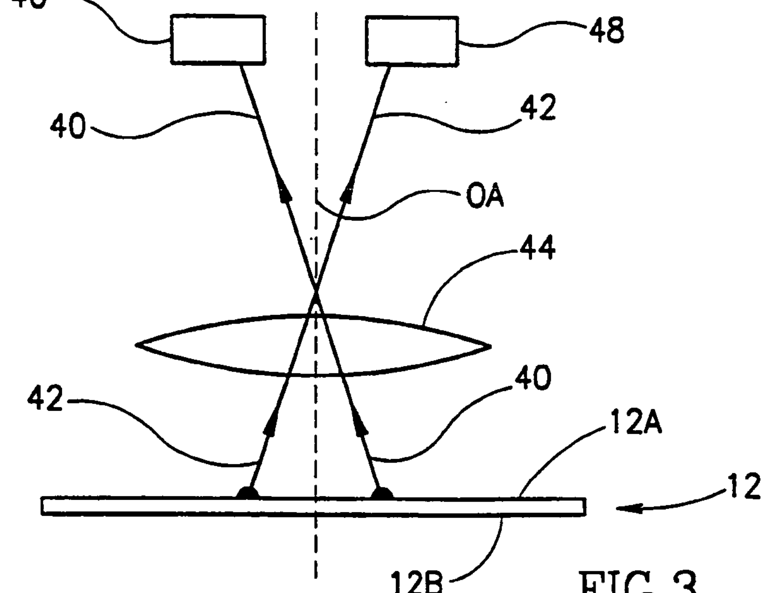


FIG.3

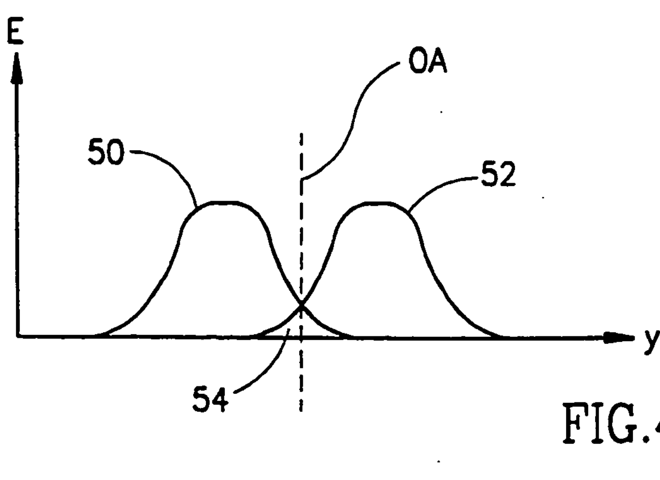


FIG.4

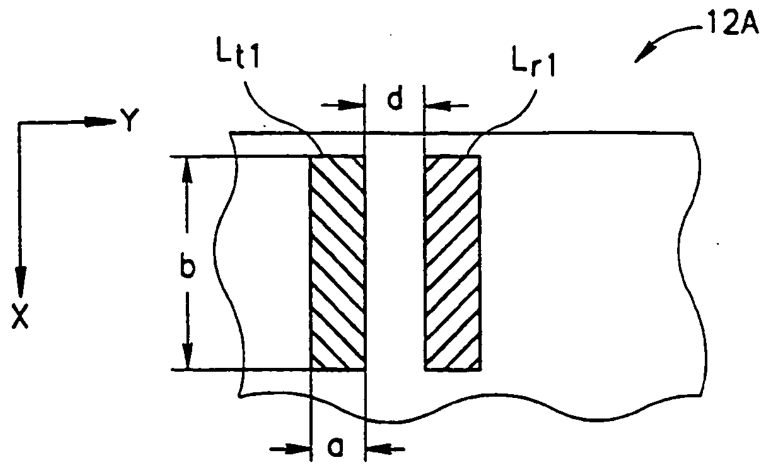


FIG.5A

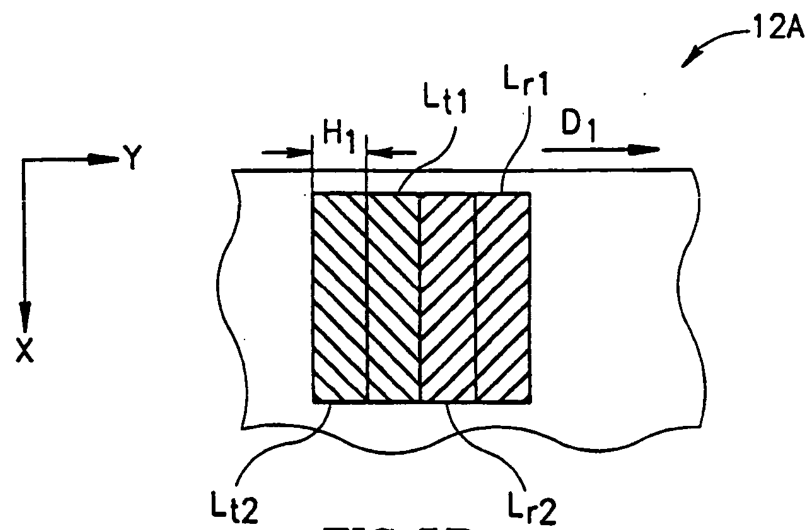


FIG.5B

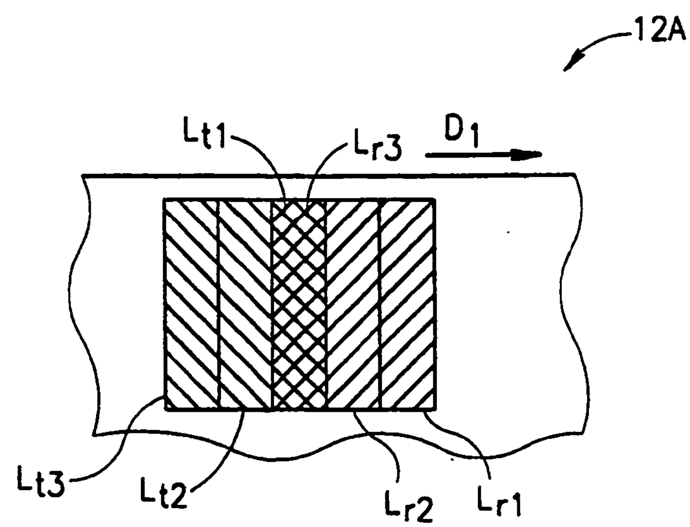


FIG.5C

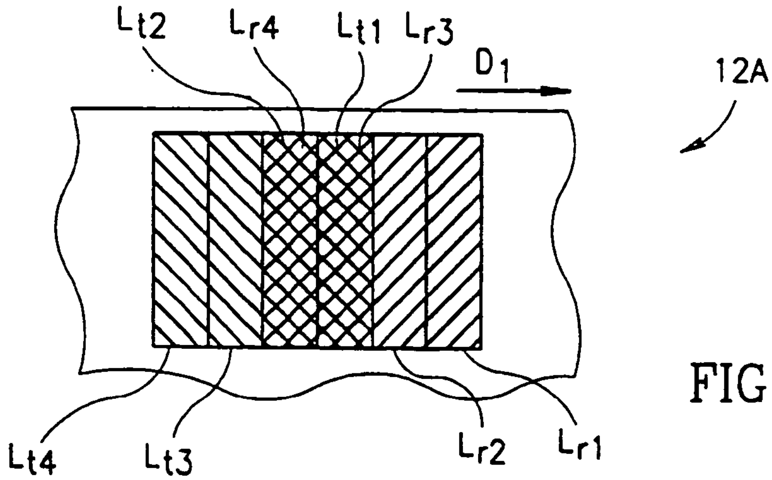


FIG.5D

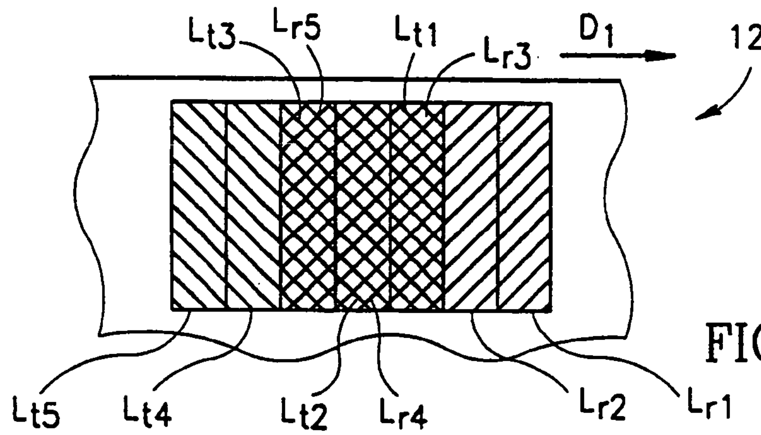


FIG.5E

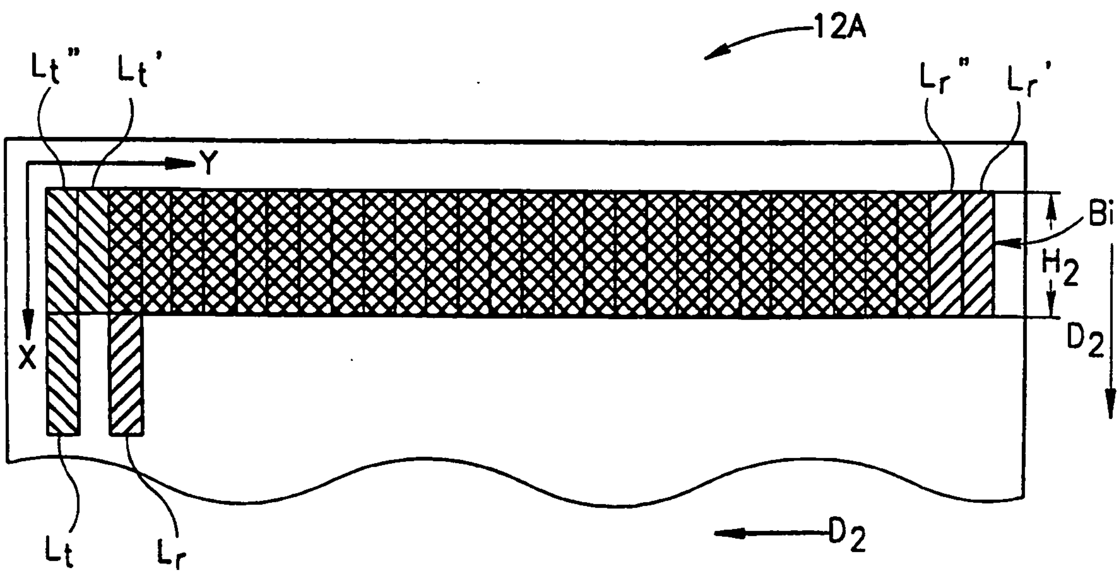


FIG.5F

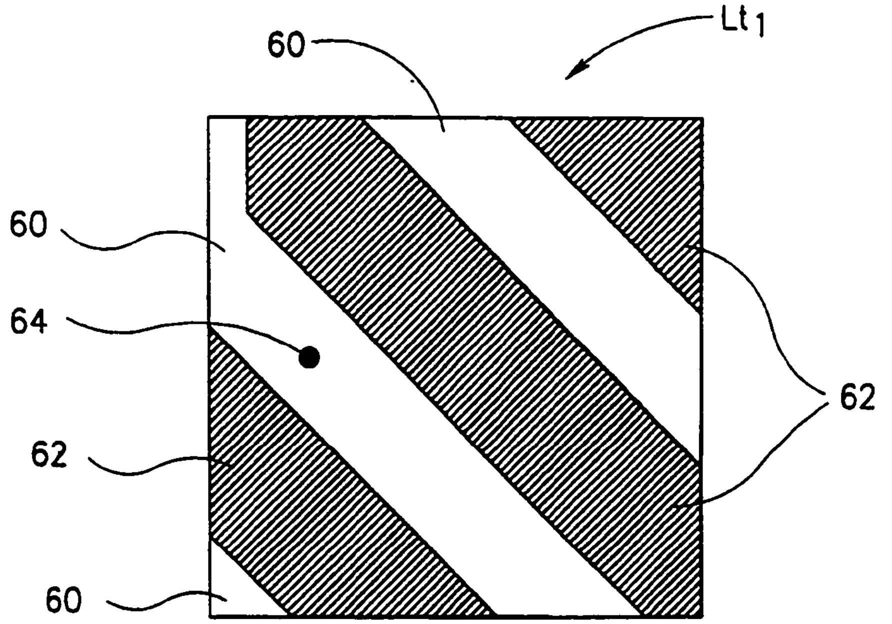


FIG.6A

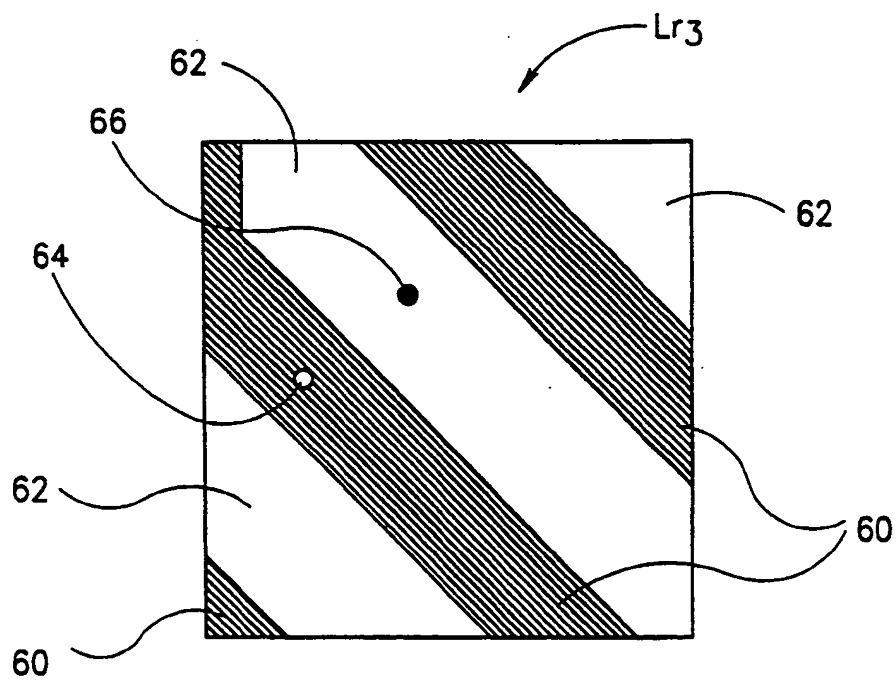
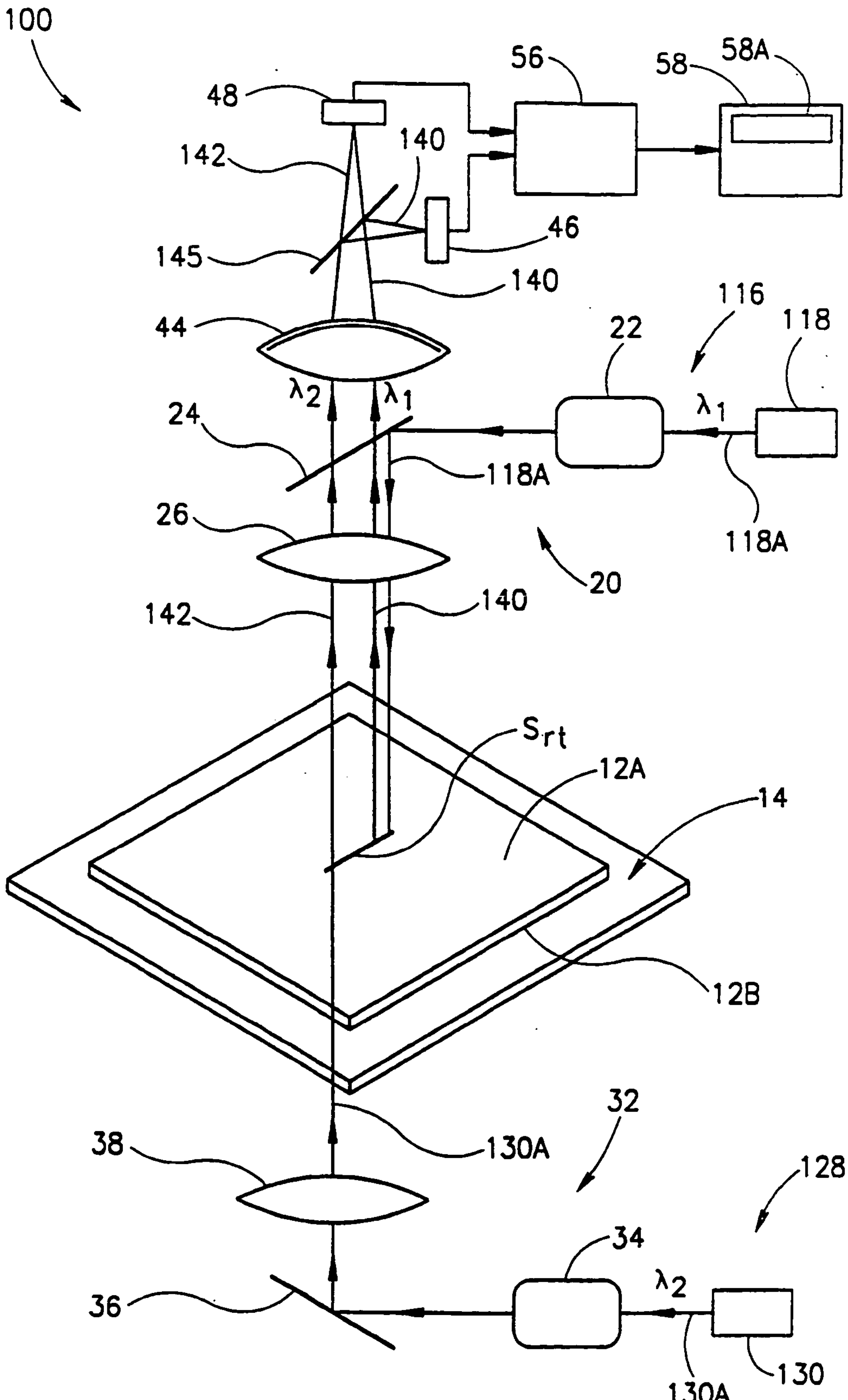


FIG.6B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λ_1
λ_1
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118A
26
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S_{rt}
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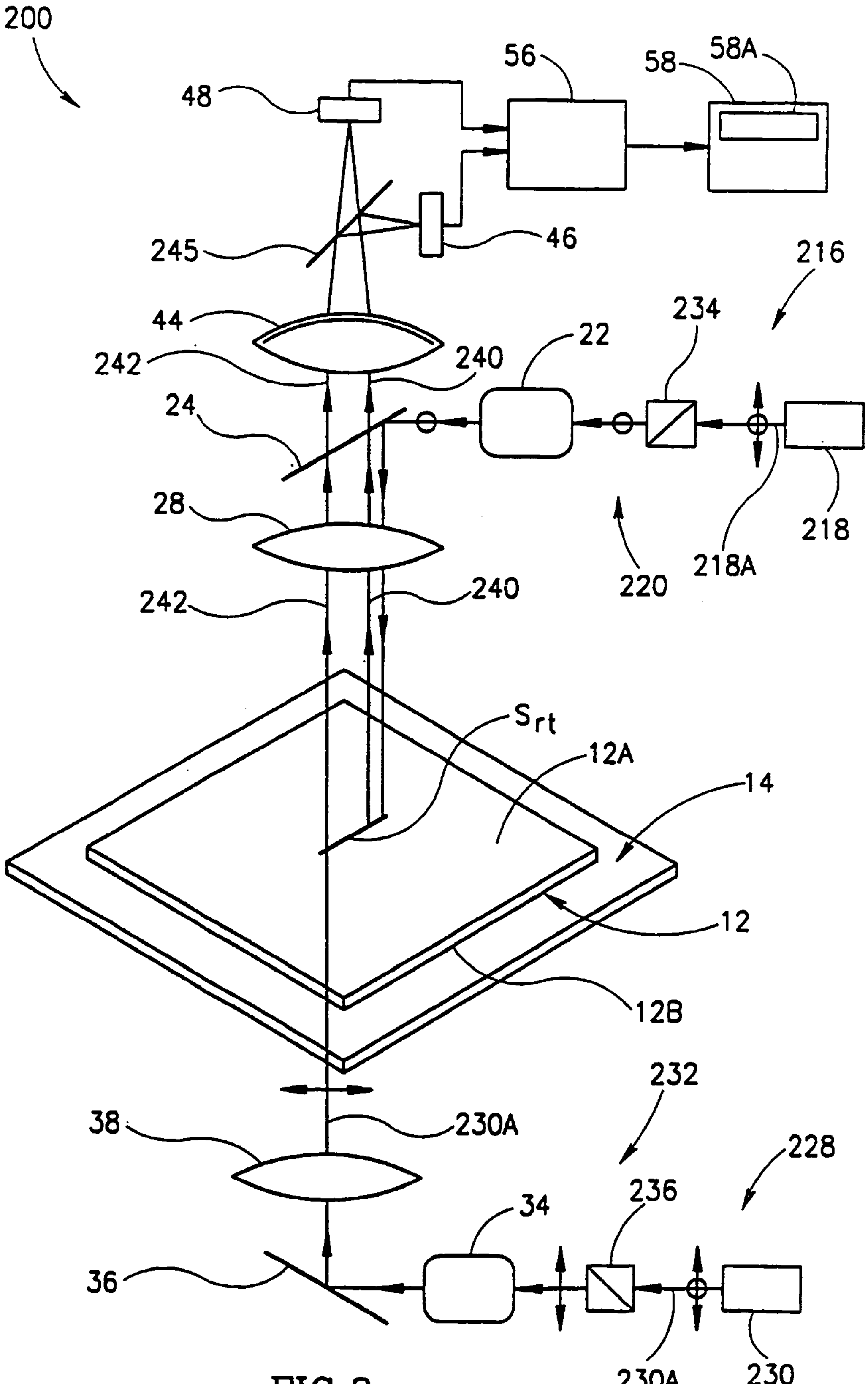
12B
32
38
130A
128
34
λ_2
36
130A
130

FIG.7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12B
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230A
228
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34
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230A
230

FIG.8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/01107

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01N21/88

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01N G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 386 112 A (DIXON ARTHUR E) 31 January 1995 see column 5, line 43 - column 7, line 11; figure 4 ---	1,3,6-8, 11,12, 14,16, 17,20, 22,23
A	EP 0 819 933 A (ORBOT INSTR LIMITED) 21 January 1998 see column 3, line 31 - column 4, line 35 see column 5, line 50 - column 6, line 3; figures 1,7 --- -/--	1,7,8, 10-17, 21-23

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 May 1999	17/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Scheu, M

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INTERNATIONAL SEARCH REPORT

Internatio Application No
PCT/US 99/01107

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,X	EP 0 838 679 A (NIPPON ELECTRIC CO) 29 April 1998 see column 2, line 26 - line 37 see column 5, line 42 - column 8, line 14; figures 1,6 -----	1,2,4,8, 11,14, 16,18, 20-23

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/01107

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